



Computational and Collaborative tools for Composite Materials



**National Materials
Advisory Board
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Accelerated Insertion of Materials – Composites (AIM-C)

Jointly accomplished by a Boeing Led Team and the U.S. Government under the guidance of the Office of Naval Aviation Systems Technology

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AIM-C Alignment Tool

The objective of the AIM-C Program is to provide concepts, an approach, and tools that can accelerate the insertion of composite materials into DoD systems.

AIM-C Accomplishes This Three Ways

Methodology - *Evaluates the historical roadblocks to effective implementation of composites and offers a process or protocol to eliminate these roadblocks and a strategy to expand the use of the systems and processes developed.*

Product Development - *Provides a software tool that facilitates evaluation of composite materials for various applications.*

Demonstration/Validation - *Provides a mechanism for acceptance by primary users of the system and validation by those responsible for certification of the applications in which the new materials may be used.*

All tasks in Phase 1 support development of a Phase 2 Transition Program



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Accelerated Insertion of Materials Is Achieved in AIM-C Methodology by

- Focusing on Real Insertion Needs (Designer Knowledge Base)
- Approach for coordinated use of
 - Existing Knowledge
 - Validated Analysis tools
 - Focused Testing
- Application of Physics Based Material & Structural Analysis Methods
- Use of Integrated Engineering Processes & Simulations
- Uncertainty Analysis and Management
 - Early Feature Based Demonstration
 - Tracking of Variability and Error Propagation Across Scales
- Rework Avoidance
- Disciplined approach for pedigree management

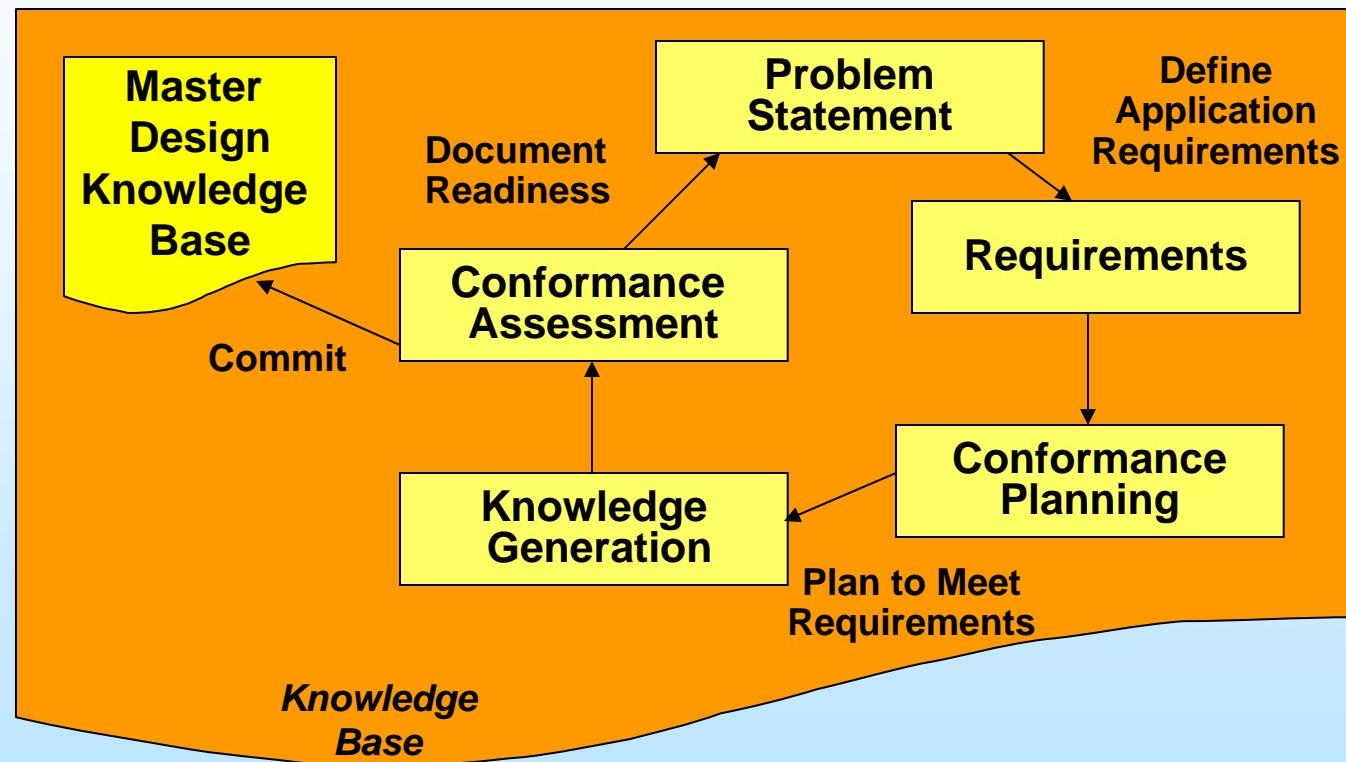
Orchestrated Knowledge Management to efficiently tie together the above elements to DKB



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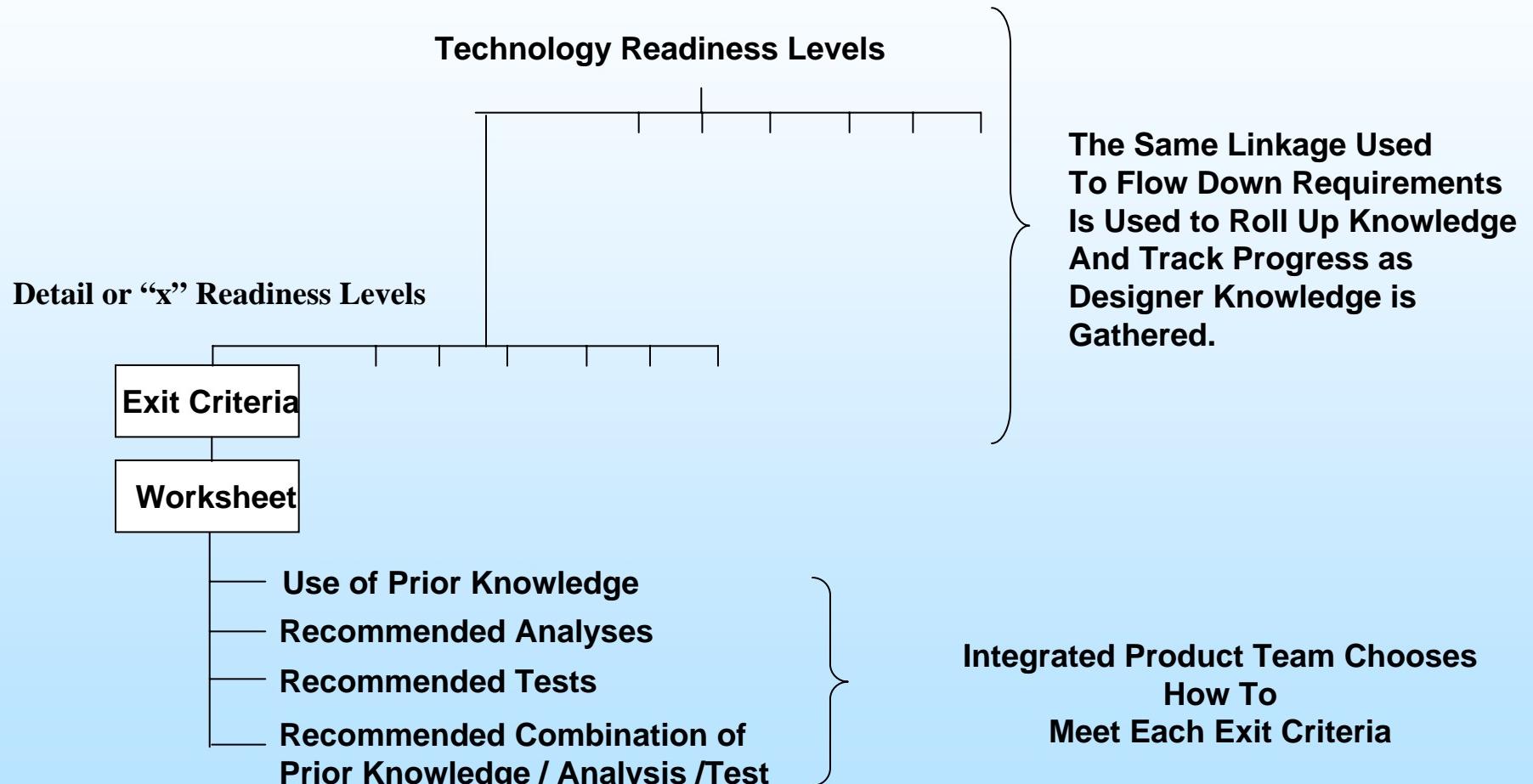


How Does the IPT Use AIM-C Methodology?





Knowledge Gathering

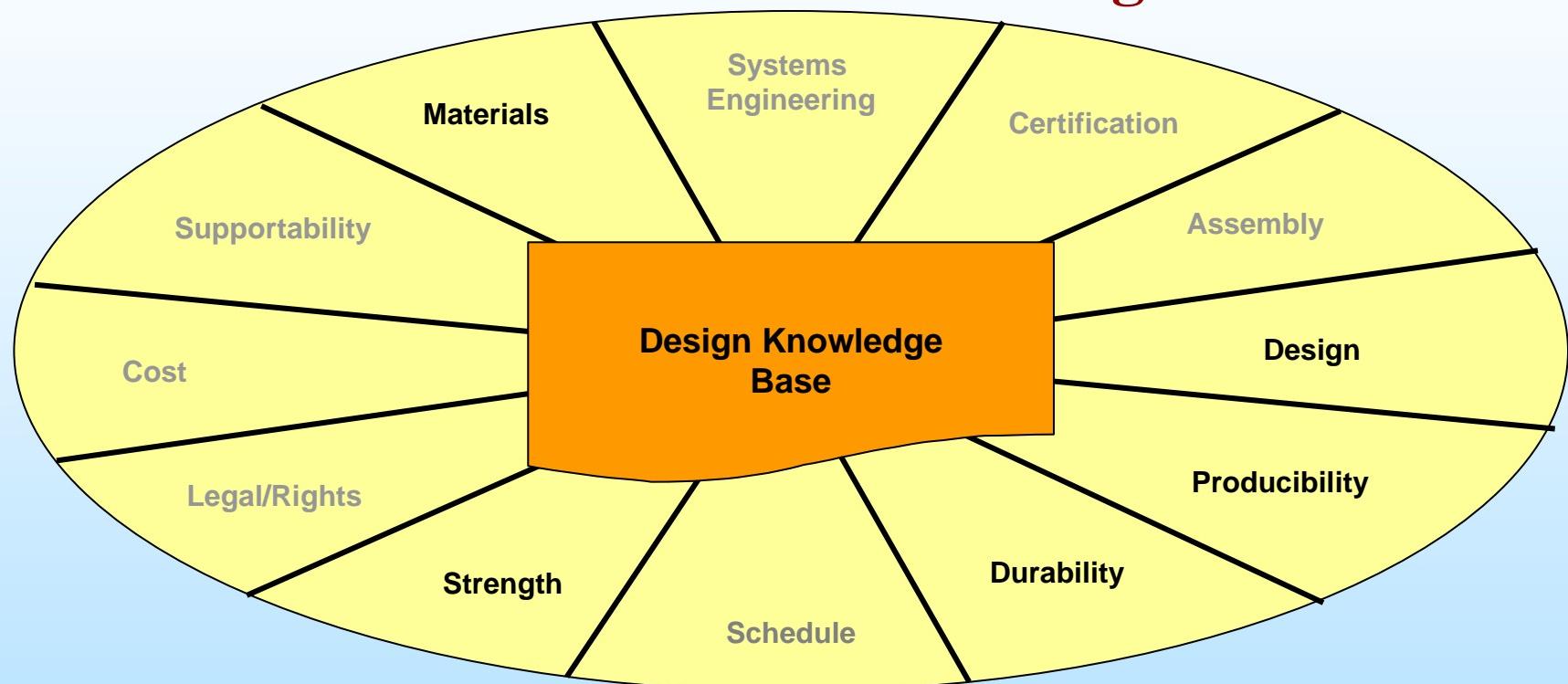


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The AIM-C Process Uses an Integrated Product Team to Commit Data to the Knowledge Base



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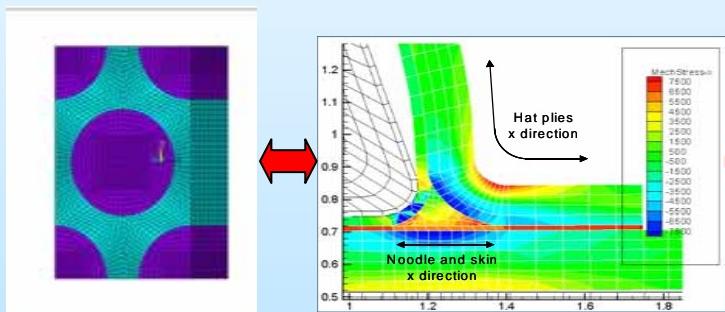
Use of AIM-C



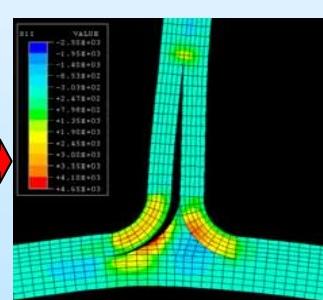
Web-Based System Delivery

AIM-C Technology Readiness Summary									
Codes	YES (Working)	NO (not done)	In-Work	Problem	N/A				
AI-1	Y	N	N	N					
AI-2	N	N	N	N					
AI-3	N	N	N	N					
AI-4	N	N	N	N					
AI-5	N	N	N	N					
AI-6	N	N	N	N					
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Process Guidance and Risk Reduction Status

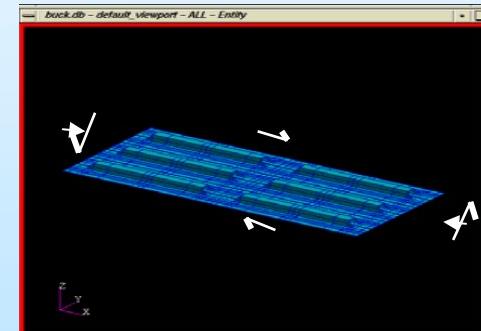


AIM-C Contains
Analytical Models
From Constituents



To Processing

To Effects of Defects



To Structural Reqs.



To Provide Analysis
Supported by Test
To Technology
Readiness

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Handling Uncertainty – The AIM-C Approach

- The First Step is Identifying and Understanding potential error sources
 - Maintains Visibility of potential errors
 - Forces step-by-step breakdown of the analysis/test process
 - Forces agreement on responses of interest
- Classifying them allows the team to determine appropriate strategies for addressing them.
- Types:
 - Aleatory Uncertainty (Variability, Stochastic Uncertainty)
 - Epistemic Uncertainty (Lack of Knowledge, e.g., unknown geometry)
 - Known Errors (e.g., mesh convergence, round-off error)
 - Unknown Errors (Mistakes, e.g. wrong material inputs used)



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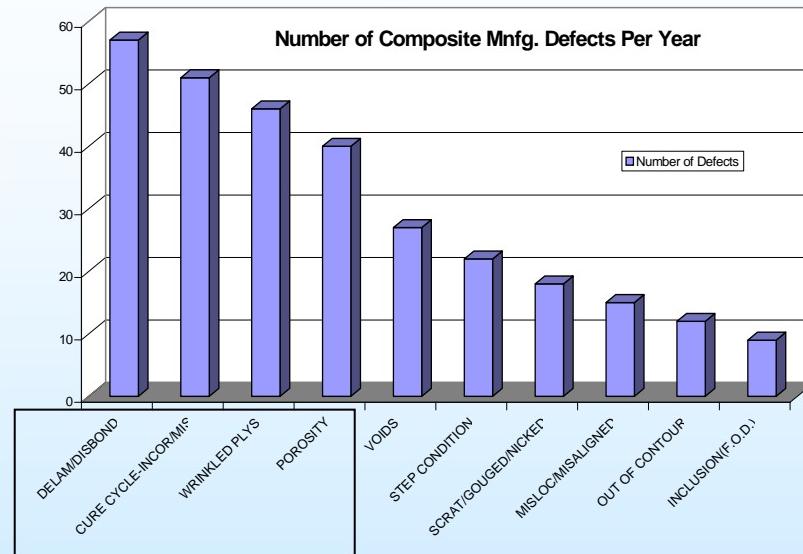


Handling Uncertainty – The AIM-C Approach

- Prior knowledge is useful in determining likelihood of occurrence.

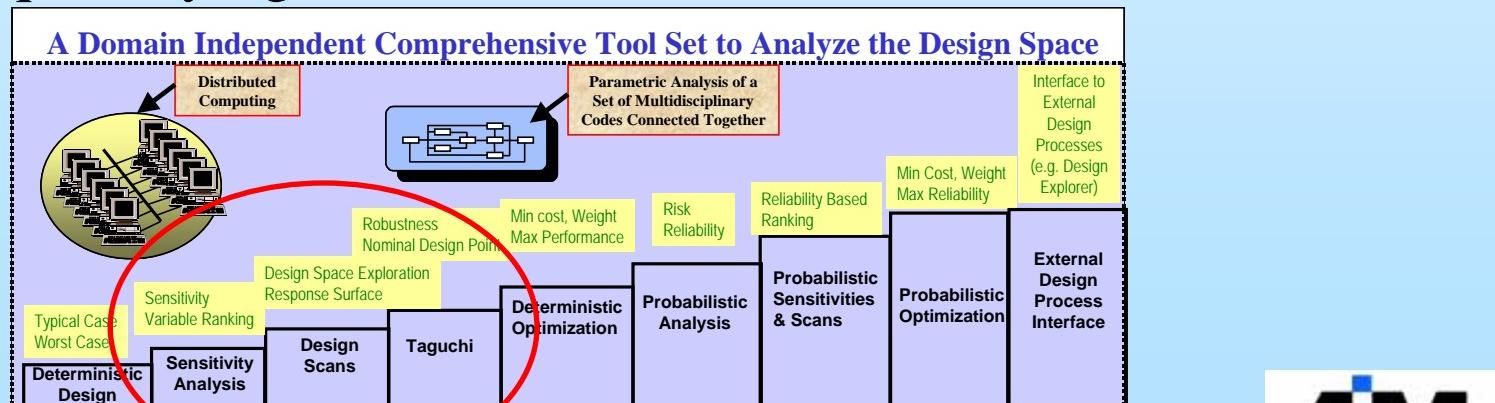
Example: Past experience with Similar designs suggest that 3/4 of Stiffened panel defects are:

- Delaminations
- Cure Cycle Inconformities
- Ply wrinkles, or
- Voids/Porosity



- Tools such as DOE/ANOVA and Sensitivity Analysis are useful in quantifying a variable's influence on the result.

Robust Design Computational System (RDCS)

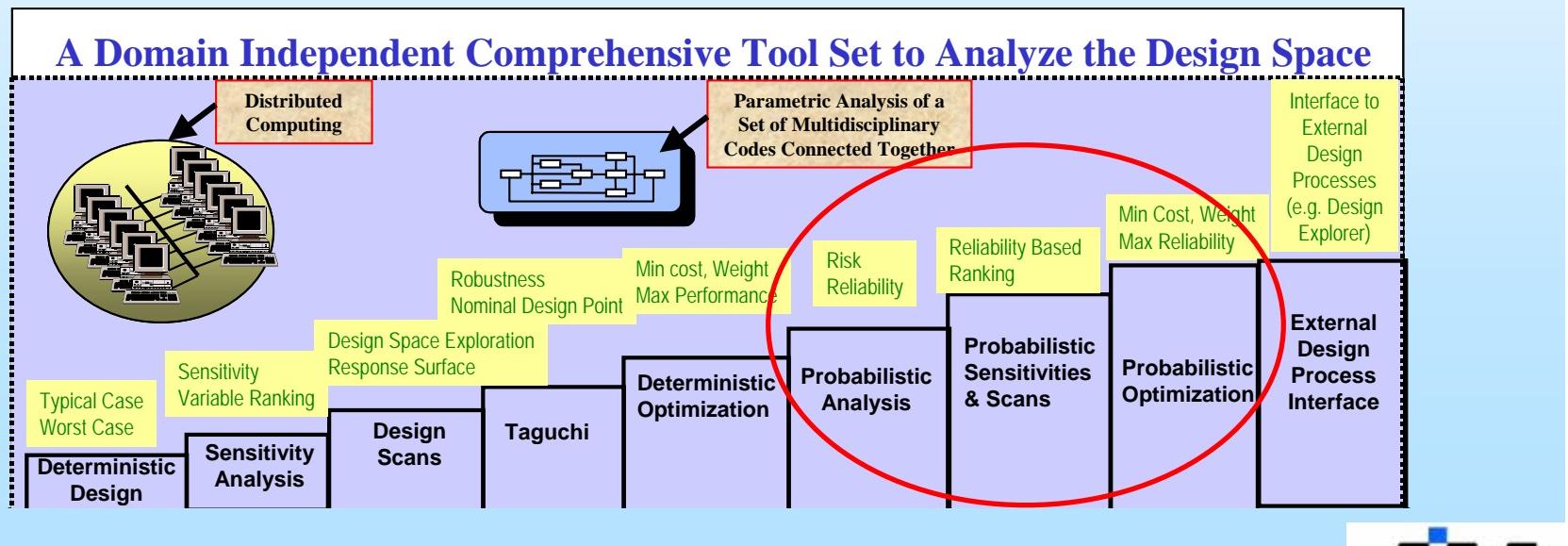


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Handling Uncertainty – The AIM-C Approach

Quantifying Uncertainty

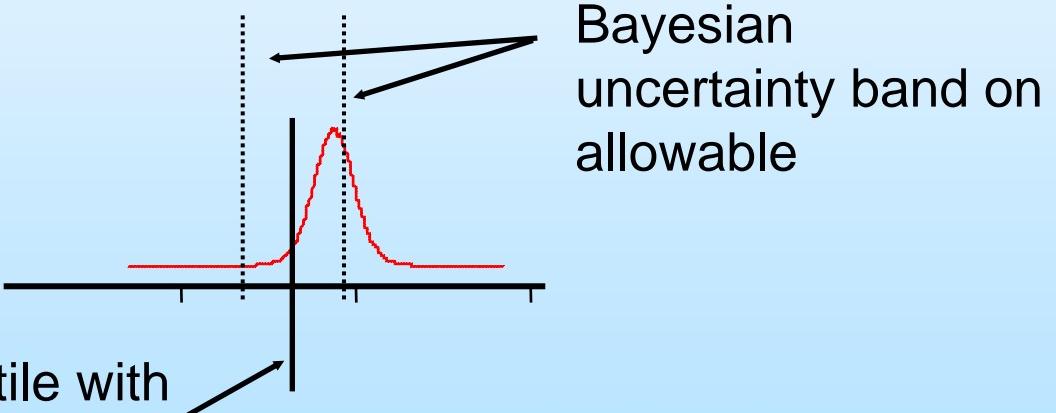
- If its important, and you can't remove it by design, quantify it.
- Testing or Probabilistic Analysis Tools are applied.



Data from Knowledge, Analysis, and Test

Combined Data – Allowables with Uncertainty

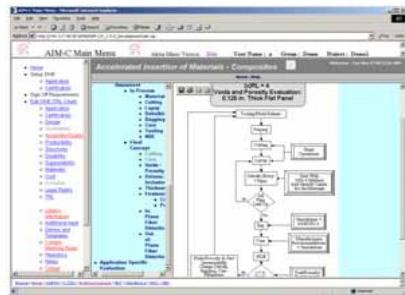
- Data contain replicates => can estimate stress allowables (quantiles with confidence bands)
- RDCS allows simulation of physical data with sources of randomness including batch effects (aleatory or random uncertainty) => can simulate allowables.
- Combined data: allowables with uncertainty bands



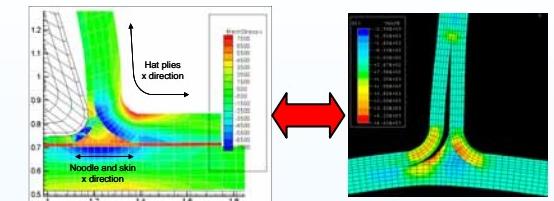


DKB Re-creation

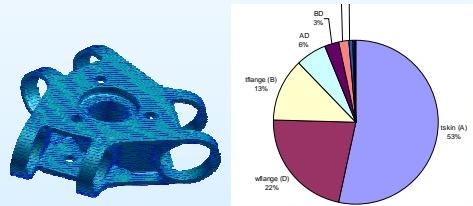
Encoded Heuristics



Producibility

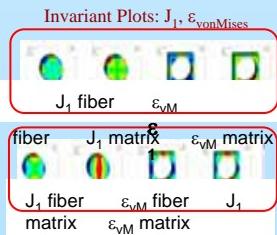


Processing data passed to Structural Analyses

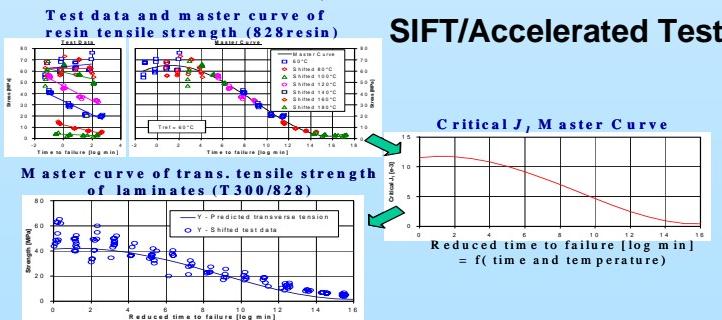


Design, ANOVA, Design Explorer, & Probabilistic Optimization RDCS Links

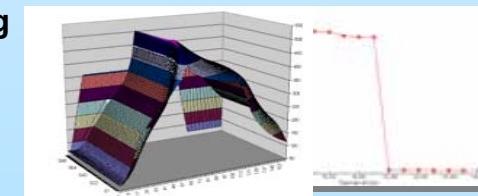
Physics Based 3D SIFT & Fracture Failure Theories



Structures²



SIFT/Accelerated Testing



Materials & Processing

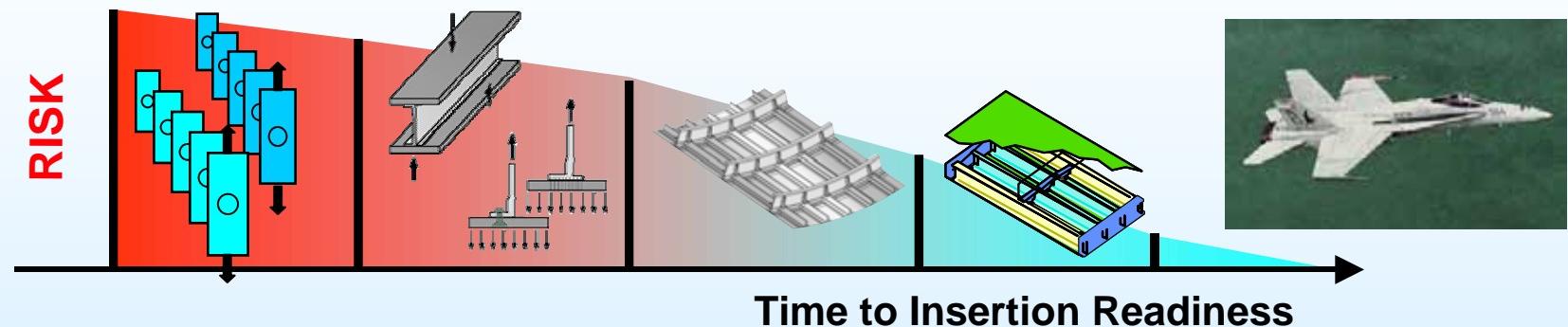


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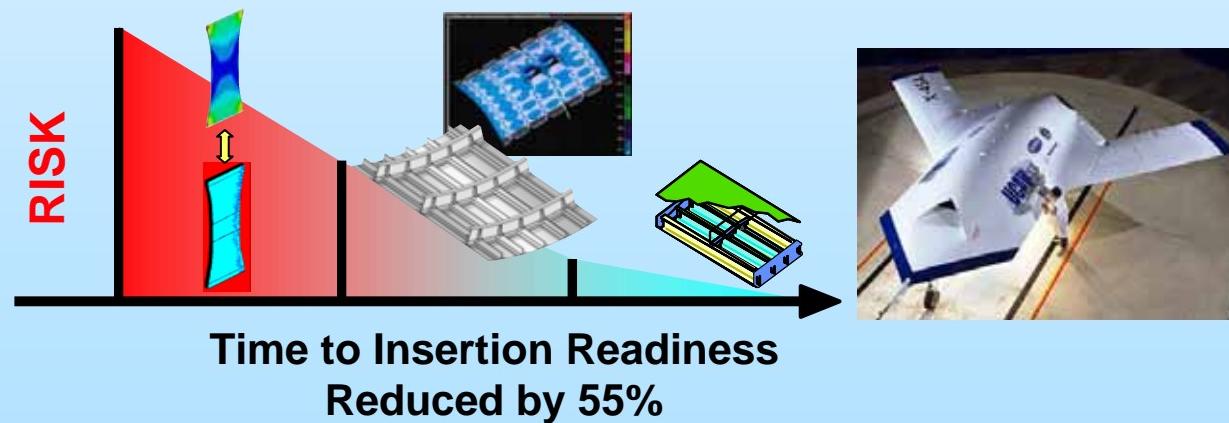


What's the Benefit of AIM-C?

Traditional Test Supported by Analysis Approach



AIM Provides an Analysis Approach Supported by Experience, Test and Demonstration



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